

## Chapter 3 Quality Control and Quality Assurance Standards

### 3-1. General

If good QC procedures are designed and adhered to, then a quality mapping product is assured. Overall QC is the responsibility of the mapping contractor, and is exercised at specific stages of the map production process. The Government's role during data acquisition and map/data base compilation should generally be limited to performing QA, which may involve only cursory spot-checking of the maps, or to performing formal field map testing using Government or third-party forces. The scope of contractor QC and Government QA effort is driven by the functional uses of the end product, acceptable omissions, and accuracy tolerances. Since there is no perfect map product, the magnitude of QC and QA performed must be economically commensurate with the mapping and/or engineering project.

*a. Minimizing rework.* Proper QC does not increase the cost of the product. The earlier in the production process a mistake, blunder, or carelessness is caught, the less rework and the less the final cost (whether the cost of rework is borne by the Government or by the contractor). When defects must be reworked, increased cost through lowered productivity results. By reducing waste, cost will also be reduced.

*b. Categories of quality control.* Quality control on photo mapping work may be divided into two categories: process control and product assurance.

(1) Process quality control. Process QC is primarily the responsibility of the contractor. This includes contractor QC reviews of flight alignments, photographic quality, stereocompilation, map accuracy, and map completeness. The degree of QC required of the contractor will be governed by the contract specifications, and should be developed based on the end functional use of the map product. On projects involving utility relocations, contractor field map classification and edit would be critical, and labor for this work must be scheduled in the contract or delivery order. For a small-scale Geographic Information System (GIS) developing land use classifications, extensive field edit would not be necessary. Due to limited USACE resources, QC responsibility is usually fully placed on the contractor.

Some Federal agencies maintain QC; however, this is usually due to their use of low-bid mapping procurement rather than qualification-based methods used in USACE. For example, the Government may require its inspection of the photographs prior to the contractor's beginning to triangulate or to compile; submission of field survey data for its review and approval; a printout of the aerotriangulation adjustment prior to continuation; or a phased delivery and inspection of a percentage of the mapping or other products before authorizing the remainder. However, this type of control by the Government of the contractor's interim work phases may prove counterproductive, and should not be exercised except on large and critical mapping projects. In addition, the Government must possess the in-house technical expertise to reliably assess interim submittals by the contractor.

(2) Product quality assurance. The Government's primary role is that of product QA. Product quality will be assured by the Government using a variety of inspection and testing techniques on the final deliverables. The Government may perform product QA using Government employees or third-party contractors, or through agreement with, and oversight by, the photogrammetric mapping contractor. Product assurance checks, tests, or field inspections are called for in the contract; however, the Government has the option to waive any or all tests and accept the delivered product without formal field testing/checking.

### 3-2. Contractor Quality Control

The contractor will be responsible for internal QC functions involved with field surveying, photography and laboratory processing, stereocompilation, drafting, and field checking and editing of the photogrammetrically made measurements and compiled maps to ascertain their completeness and accuracy. Also, the contractor will make the additions and corrections that are required to complete the maps and photogrammetrically made measurements.

### 3-3. Quality Assurance of Maps

The mapping contractor is responsible for assuring, through QC efforts, that deliverables meet the required accuracy and content specifications. The Government may perform such QA checks as necessary to verify the quality of maps by final inspection and/or testing of the delivered products. Due to Government resource and economic limitations, formal QA checking or testing

described in *c* below is optional, even though it may be called for in the contract. On many projects, the contractor's QC program may be deemed sufficient to assure the adequacy of the product. cursory field spot checks by the Government may be adequate on other projects. If excessive errors or omissions are suspected or uncovered, then formal field testing may have to be performed unless the contractor willingly corrects any such deficiencies.

*a. Applicable standards.* The USACE standards delineated in Chapter 2 will be the applicable standards for quality control and subsequent quality assurance map testing of all map or spatial data products delivered. These standards are necessary for contract enforcement should the contractor not willingly correct deficiencies at his own time and expense.

*b. Timeliness.* The Government will complete all QA checks or tests as quickly as practical. Each map sheet will, within 30 days after receipt of the finished map sheets, be accepted, be returned for correction, or be rejected for recompilation. The contractor will correct returned map sheets and/or replace rejected map sheets within 30 days after receipt of the returned sheet or notice of rejection.

*c. Testing.* All tests for accuracy will be made on the map manuscript, the finished map, or a copy of the map on scale-stable material at the target scale specified in the contract. All maps compiled may be subject to map testing by the Government, by independent third-party forces, or by contractor forces working under direct Government review to ensure that they comply with the applicable accuracy requirements. Map test results will be statistically evaluated relative to the contract-defined accuracy criteria (e.g., ASPRS), and a pass/fail determination will be made accordingly. The decision of whether or not to perform rigid map testing on any project, delivery order, or portion of a project rests with the Contracting Officer. In all cases, the contractor will be advised in writing when such action will be taken.

*d. Office and field checks.* The party responsible for map testing may, during the course of the project, inspect map compilation in the contractor's facility by comparing them with aerial photographs. However, the final map compilation will normally be checked by field inspection. Horizontal and vertical accuracy checks, using traverse, triangulation, and differential leveling methods will be made to test selected points or features on the completed drawings.

*e. Plotting of nonphotogrammetric data.* The Government or its designee will make appropriate measurements to verify that the coordinate grid is square and correctly spaced; that the positions of control points and property corners agree with their surveyed coordinates; and that labeling of designation, horizontal coordinates, and elevation is correct.

*f. Methods of testing.* Preliminary checking of map content for completeness may be done by comparing the map with photographs taken from the air or from the ground. The final check will be a field check comparing the map with conditions on the ground. The geometrical accuracy of map features may be evaluated by comparison to ground surveys, aerotriangulation, or the stereoplotter. Comparative procedures and evaluation methods must be in conformance with the requirements of the contract or the referenced specification (e.g., ASPRS).

(1) Ground surveys. Traverses and level circuits for testing the accuracy of planimetry, spot elevations, contours, and cadastral points will start and close on monuments of the National Geodetic Reference System (NGRS), on a state or local network designated by the contract, or on station markers and benchmarks of the basic control survey for the project. The surveys will be made to the standards of accuracy required for the basic control survey for the mapping project and conform to the referenced specification accuracy requirement.

(2) Aerotriangulation. If the supplemental control survey for the project is by aerotriangulation, coordinates of points to be used for testing may be produced as part of the supplemental control survey. Point data can be produced for testing planimetry, spot elevations, or stereoplotter setup for testing. The aerotriangulation used to produce test data will meet all specification requirements for controlling the plotting of the map features to be tested.

(3) Stereoplotter. Maps may be tested for completeness and for accuracy of planimetry, spot elevations, and contours by setting the map and transparencies of photographs of the mapping area in a stereoplotter, orienting the photographs to the control plotted on the map, and making appropriate measurements.

(a) Operator. Testing by stereoplotter will be done by a competent, experienced Government operator using a properly calibrated stereoplotter, which, with the original photographs or diapositives, is capable of making

measurements of comparable accuracy to that of the instrument used by the contractor.

(b) Contour factor. When a topographic map is being tested, the contouring factor, or the ratio of flight height to the smallest CI accurately plottable, of the stereoplotter used by the Government will be comparable to that used by the contractor during original compilation.

(c) Verification. The Government may also verify the accuracy of stereoplotter map testing performed by the contractor by requiring the contractor's operator to report the horizontal and vertical coordinates of specified readily identified points. The Government will have measured the coordinates of these points by ground surveys or by aerotriangulation.

*g. Testing of features.* Map features will be tested as set forth below:

(1) Planimetry. The accuracy of the planimetric map feature compilation will be tested by comparing the ground coordinates (x and y) of at least 20 well-defined map features per test per map sheet, as determined from measurements on the map at publication scale, to those for the same points provided by a check survey of higher accuracy. The check survey will have an order of accuracy and procedures as specified for establishing the mapping control. Maps will also be examined for errors and/or omissions in defining features, structures, utilities, and other nomenclature, or for total gaps in compilation/coverage. The minimum of 20 points will be distributed throughout the sheet or concentrated in critical areas. Tests will be made on well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as intersections of roads or railroads and corners of buildings or structures. In general what is well-defined will also be determined by what is plottable at the scale of the map within 1/100 in. Thus, while the intersection of two property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practical. Points that are not well-defined are excluded from the accuracy test. The selection of well-defined points will be made through agreement between Government and the contractor. Generally it may be more desirable to distribute the points more densely in the vicinity of important structures or drainage features and more sparsely in areas that are of lesser interest. Further definitions and requirements for selection of well-defined photo/map

points are typically found in the map accuracy standard used. The locations and numbers of map test points and/or test profiles will be mutually agreed to by the contractor and Contracting Officer's Representative (COR).

(2) Coordinates. Coordinates of planimetric features as measured on the map will be compared with coordinates of the same features as determined by ground surveys or by aerotriangulation. Planimetric features may also be checked by stereoplotter.

(3) Spot elevations. A minimum of 20 points will be checked. These points will either be distributed throughout the sheet or concentrated in critical areas. Spot elevations will be compared with elevations determined by field or photogrammetric methods. The test for vertical accuracy will be performed by comparing the elevations at well-defined points determined from the map to corresponding elevations determined by a survey of higher accuracy.

(4) Contours. The accuracy of contouring will be tested by comparison of a profile measured on the map with a profile measured by ground surveys, or with a profile measured with a stereoplotter or analytical plotter. The location of each test traverse will be designated by the Government. The elevation and station will be recorded for each break in the terrain and for each contour elevation. Ground-surveyed profiles will be at least 6 in. long at final map scale, with an elevation measured at least every 100 ft on the ground, and should cross at least 10 contour lines when possible. Profiles measured by stereoplotter will be at least 10 in. long at finished map scale, and the true elevation will be recorded where each plotted contour crosses the profile line. Profiles should start and close upon map features or previously established control points. In flat areas and at principal road and rail intersections, spot elevations will be checked. In general, one profile per map sheet is sufficient.

*h. Acceptance.* A map sheet or a mapping project will be accepted when the Government or its designee has performed sufficient testing to assure that each phase of the mapping meets the Government standards and specifications.

*i. Rejection.* When a series of sheets are involved in a mapping project, the existence of errors (i.e., map test failure) on any individual sheet will constitute prima facie evidence of deficiencies throughout the project (i.e., all other sheets are assumed to have similar

deficiencies); and field map testing will cease. After correction of the work, the contractor will be responsible for payment of the cost of map testing required on the corrected drawings. When such efforts are performed by Government survey employees, these costs will be deducted from contract/delivery order payment estimates. There are two reasons for which a map sheet is unacceptable.

(1) Returned for correction. If testing shows that the map is incomplete or has a few isolated errors, the map sheet will be returned for correction. The corrected map will be subject to the same extent of testing as for a new sheet.

(2) Rejected for recompiling. A map sheet may be rejected if it fails to meet specifications in any one phase of the mapping. If testing shows extensive errors or general inaccuracy, the map sheet will be rejected and a new sheet compiled. The new sheet will be subject to the same extent of testing as was the original (rejected) sheet. If a map or a map sheet is found to be incomplete, it will be returned for completion. This may be for addition of specific items found missing, or if missing items are numerous, for general completion.

*j. Criteria.* The following criteria will be used for the acceptance, return for correction, or rejection for re-compilation of a map:

(1) Coordinate grid. Any error beyond specification tolerances (1/100 in.) in spacing or orthogonality of the coordinate grid may be cause to reject the map sheet for recompiling.

(2) Control points. Any error beyond specification tolerance (1/100 in.) in plotting or any error in labeling the elevation of control points may be cause to reject the map sheet for recompiling, unless the photogrammetric contractor can demonstrate that the erroneous data were not used in setting up the photogrammetric instrument or as a basis for ground mapping measurements.

(3) Cadastral points. Any error beyond specification tolerance (1/100 in.) in plotting of cadastral points may be cause for return of the map sheet for correction.

(4) Horizontal positions. A map sheet will not be rejected for recompiling because of error in the horizontal position of planimetric or topographic features or spot elevations (not control points) unless at least

20 points were tested. If fewer than 20 points were tested and excessive errors were found, the map sheet may be returned for correction of the errors.

(5) Elevation rejection. A map sheet will not be rejected for recompiling because of errors in labeling the elevations of spot elevations (not control points) but will be returned for correction.

(6) Test profile for contours. The contours of a section of a map may be accepted on the basis of a single test profile, performed either by ground surveying or by stereoplotter.

(7) Additional test profiles. When the first ground surveyed test profile indicates that a map sheet fails to comply with accuracy requirements, an additional test profile will be made. This profile will be generally parallel to the first profile at a distance from the first as specified by the Government. No map sheet will be rejected unless the sum of the lengths of the test profiles completed is 12 in. or more at finished map scale. To determine acceptability of the contouring, the data from all the profiles will be combined and treated as a unit.

(8) Stereoplotter test. When the profile measured by stereoplotter indicates that a map sheet fails to comply with accuracy requirements, a test traverse may be surveyed on the ground to determine conclusively whether the map will be rejected.

*k. Intensity of testing.* The standards set forth in Chapter 2 do not state the intensity of the tests to be made. This subsection provides additional guidance. It is applicable only should the Government exercise its option to perform full field map testing on a given contract or delivery order.

(1) Mapping project. At least one map will be tested for each mapping project or mapping contract.

(2) Area mapping. Test points will average at least one for every 10 sq ft of map at finished map scale, with a minimum of 20 points.

(3) Linear mapping. Test points will average at least one for every 50 linear feet (lin ft) at finished map scale.

(4) Additional tests. Additional tests will be made when there is reason to suspect the quality of the mapping in general or at any specific location.

(5) New contractors. When the Government has no previous experience with a contractor's products, a more

extensive inspection may be performed than for the products of established contractors.